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Original Article

Skin temperature rhythmic fluctuations of students engaged in aerobics as an endogenous factor of adaptation to external environment

YURI ROMANOV[1], ALBERT AMINOV[2], ELENA ZADORINA[3], ELVIRA LATYPOVA[4]
[1,2,3,4,]South Ural State University (National Research University), Russia, Chelyabinsk

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Abstract.
The paper aims to study the effect of moderate cooling on maintaining temperature rhythmic fluctuations of the skin surface in students engaged in aerobics. Measurements were performed before and after warming up at an ambient temperature of 20-21°C. Students were characterized by a different fat status. Materials and methods: 30 female students were examined using Tanita BC-418 MA analyzer (Japan) to determine the percentage of adipose tissue (AT) and body water. Six students with adipose tissue in the range from 7.4% to 24.8% were selected. The signal was recorded twice for 10 minutes from the front surface of the body with a BALTECH TR-01500 thermal imager (Germany). Results: according to the data in the form of average values of skin temperature (above the region of the quadriceps of the left leg), graphs of changes were built in Microsoft Excel. The analysis of temperature fluctuations confirmed the hypothesis that each individual has his/her own temperature biorhythm. Conclusion: in spite of the warm-up period that disrupts the performance of the thermoregulatory system, the temperature fluctuations returned to the initial biorhythm triggered by moderate cooling. This may indicate that maintaining thermal balance allowed the thermoregulation system to effectively control temperature homeostasis due to the natural, genetically determined temperature biorhythm.
Keywords: thermoregulation, homeostasis, temperature rhythmological fluctuations, female students.

Introduction

The fundamental property of living matter is rhythmic fluctuations which is manifested in the form of continuously interconnected vibrations of all biochemical and functional processes. Adaptation of an organism to environmental conditions is greatly facilitated by biological rhythms that ensure the mechanisms of regulation of vital functions. Biorhythms are found at all levels from molecular and subcellular to the biosphere. However, despite the many expressed concepts, hypotheses, and models for generating biorhythms (genetic, cellular, multi-oscillatory), until recently, the nature and mechanism of biorhythms have not been elucidated, and their research so far is a process of accumulating information, identifying properties and patterns by statistical methods. The temporal structure of rhythms is very complex and little studied, many issues related to the rhythmic organization of functions remain insufficiently studied (Yezhov, 2008; Chibisov, Agarval, Eremina, 2014; Charkoudian, 2010; Iconomescu, Ciapa, Talaghir, Badicu, 2013; Yarmak, Blagii, Palichuk, Hakman, Balatska, Moroz, Galan, 2018). Although there is an opinion that the main part of the body’s biological clock (the so-called central oscillator) is located in the suprachiasmatic nuclei (SCN) of the anterior hypothalamus. SCN neurons are independently programmed at the genetic level taking on the role of an oscillator, whose activity is determined by the rate of biochemical reactions in the cell. It is inside the cell that the biorhythm mechanism in SCN is triggered in the form of protein synthesis, which with the help of the feedback loop suppresses its own formation, then decays and is synthesized again (Kovalzon, Dorokhov, 2013; Blatteis, Lutherer, 1976; Fernández-Cuevas, Bouzas Marins, Arnáiz Lastras, 2015).

One of the most significant biomarkers of the safe performance of life-supporting systems is a thermal status, namely skin temperature, which has a high information capacity. In recent scientific papers related to biorhythmology, changes in the average temperature during the day are most often considered, as well as their correlation with performance. There are practically no studies on the dynamic change in the skin temperature of a person in microintervals, despite the fact that the temporal structure of temperature rhythms is very complicated, and the issues related to the rhythmic organization of functions are not disclosed (Aschoff, 1984; Glutkin, 2017; González-Alonso, 2012). It is possible to experimentally verify the maintenance of temperature rhythmic fluctuations under various confounding factors that arise after warm up exercises, metabolic growth, activation of the thermoregulation system, etc. (Epishev, Nenasheva, Korableva, Belenkov, Episheva, Tayebi, 2019). The observed periods of biorhythms are almost always uneven as a result of the superposition of transient processes, the integrity of biosystems, the coordination of periods of biorhythms both at the same level and between higher and lower levels of biosystems (Zaguskin, 2010; Meigal, Oksa, Gerasimova, Rintamaki, 2000).

Corresponding Author: YURI ROMANOV, E-mail: romanovyn@susu.ru

Materials and methods

The study involved 30 students aged 17-21 years. At the first stage of the experiment, we measured body length, body weight, percentage of adipose tissue (AT) and body water. A group of 6 girls with different fat status was formed. In our previous studies (Romanova, Romanov, Eganov, Komkova, 2018), results were obtained that indicate the presence of skin temperature correlations with AT values (Table 1).

Table 1. Morphofunctional characteristics of the sample

Participant №	Age, years	Body weight, kg	Body length, cm	Adipose tissue, %	Body water,%
1	21	46.12	155	7.4	67.3
2	20	48.85	168	12.1	64.5
3	20	52.63	166	17.1	60.2
4	19	51.16	155	19.3	59.1
5	19	56.09	158	22.0	57.7
6	18	53.73	155	24.8	55.1

At the second stage of the experiment, non-contact infrared thermography with a BALTECH TR-01500 thermal imager was conducted. Temperature recording was carried out in students standing in front of the thermal imager. After a 15-minute adaptation to laboratory conditions students took off their clothes to stay in swimsuits. 15 seconds after this, thermal images were taken (15 seconds are required to adjust the equipment) consisting of a series of 20 exposures (every 30 seconds) lasting 10 minutes. Then, a set of standard 15-minute warm-up exercises of medium intensity in a tracksuit was performed which caused moderate sweating. After warm up, in 15 seconds, the second series of 20 exposures (every 30 seconds) lasting 10 minutes (front view) began.

Results

After processing the images with the special Baltech Expert program, average temperature data were obtained from the front surface of the thigh of the left leg (skin area above the quadriceps) corresponding to a specific time. Based on these data, temperature graphs were constructed in Microsoft Excel, where the temperature curves (Fig. 1, 2) described the students before warm up exercises and immediately after them.
As an example, graphs of temperature fluctuations of two students are presented, which confirm the hypothesis formulated at the beginning of this paper (Fig. 1, 2).

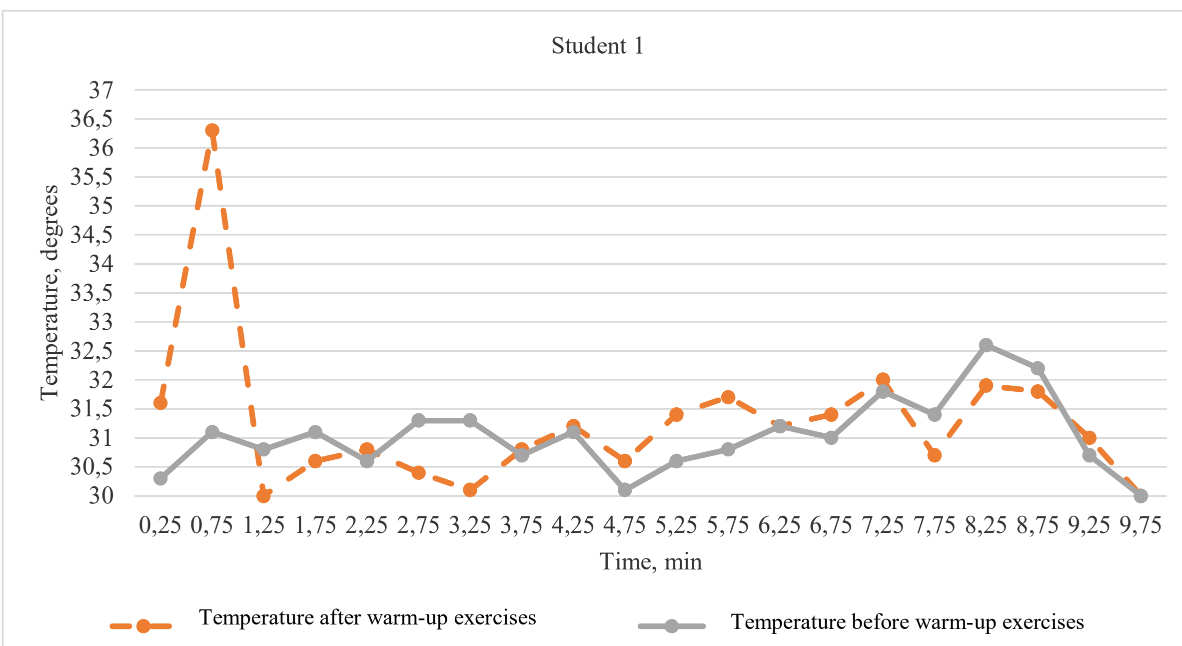

Fig. 1. Changes in the average temperature of the skin located above the quadriceps of the left leg before and after warm up exercises during a 10-minute cold exposure at muscle rest. The first student.

For example, starting from 3.75 minutes the graphs almost perfectly matched despite the powerful temperature fluctuations immediately after warm-up exercises.

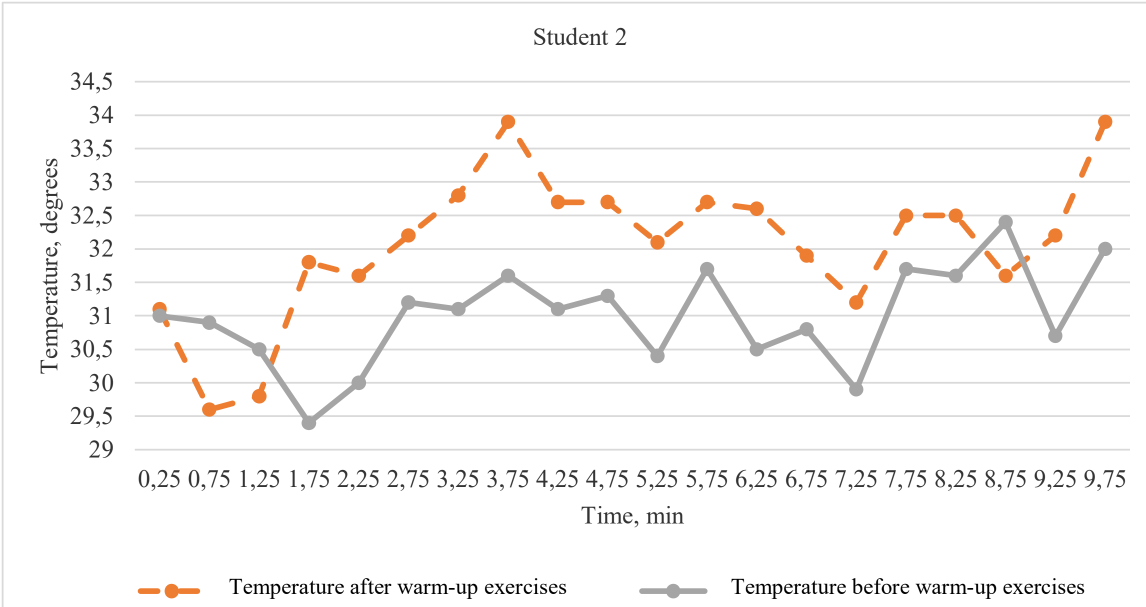

Fig. 2. Changes in the average temperature of the skin located above the quadriceps of the left leg before and after warm up exercises during a 10-minute cold exposure at muscle rest. The second student.

The vector of changes in temperature fluctuations in the second student was identified already from 1.75 minutes, although it varied slightly higher along the temperature axis due to increased metabolism as a result of 15-minute warm up exercises. It is quite obvious that these two students differed in terms of the urgent adaptation of muscle activity because of the mechanisms of heat production and heat transfer, as well as because they had different metabolic rates.

Discussion

Fluctuations always appear around some fixed level or period of oscillation. Despite the possibility of random fluctuations (noise or chaos), the experiment made it possible to test a hypothesis based on the fact that the functional systems of the human body are aimed at maintaining temperature homeostasis through the ability to ensure temperature fluctuations despite the constant distracting stimuli (Jansky, Matouškova, Vavra, 2006). Warm up exercises are almost always aimed at increasing the temperature of muscle structures and the preoptic region of the anterior hypothalamus, which contribute to sweating with simultaneous vasodilation of the skin vessels, increased blood flow to the skin (Oksa, 2002, Oksa, Ducharme, Rintamaki, 2002; Priego Quesada, Martínez Guillamón, Ortiz Cibrián, 2015), and a decrease in heat production. Skin temperature in girls after 15-minute warm up exercises characteristic of aerobics, increased to 36-38 ° C. After taking off the tracksuit, regardless of whether there was a warm up or not, due to the lower air temperature in the laboratory (at a humidity of 40% and an air temperature of 20-21 ° C, which is 10-13 ° C lower than the neutral temperature) there was a stimulation of the sympathetic centers of the posterior hypothalamus (Charkoudian, 2010; Jessen, Rabшl, Winkler, 1980; Lim, Byrne, Lee, 2008), which led to vascular spasm and increased heat production due to chemical thermogenesis during the separation of oxidative phosphorylation reactions (Kenney, Johnson, 1992; Guyton, Hall, 2008). Thermogenesis as heat generation for maintaining temperature homeostasis occurs almost constantly differing in intensity depending on the ambient temperature and metabolic status of the organism itself (Nybo, 2010; Oksa, Rintamaki, Rissanen, 1997). Two multidirectional processes associated with an increase in temperature and a simultaneous decrease in it introduced corrective effects to the rhythm of changes in skin temperature increasing the amplitude of temperature fluctuations to a greater extent. Temperature fluctuations are also observed without warm-up exercises. The difference is that there is no increase in metabolism and no sweating. Depending on which process is currently dominating, an increase or decrease in skin temperature occurs. According to the graphs, the temperature is periodically reduced and increased due to the balance between heat production and heat radiation, which is a kind of oscillatory rhythmic system. The data obtained confirm that the phenomenon of maintaining the individual temperature rhythm of the skin has not yet received a proper assessment in sports physiology, although there are probably interesting scientific prospects associated with more in-depth, fundamental analysis of the results.

Conclusions

In spite of the warm-up period that disrupts the performance of the thermoregulatory system, the temperature fluctuations returned to the initial biorhythm triggered by moderate cooling. This may indicate that maintaining thermal balance allowed the thermoregulation system to effectively control temperature homeostasis due to the natural, genetically determined temperature biorhythm.

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